Prevention of Significant Deterioration

Best Available Control Technology Determination

Clow Water Systems Company
Coshocton, Ohio

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Table of Contents

List of Tables

List of Appendices

Executive Summary

A Best Available Control Technology determination was conducted for particulate matter, particulate matter less than 10 microns, and volatile organic compounds from the possible modification to the cupola and installation of a new centrifugal casting machine at Clow, a ductile iron pipe foundry, located in Coshocton, Ohio.

Key findings of the study include the following:

- The particulate matter, particulate matter less than 10 microns, and volatile organic compound emissions from the cupola are currently controlled to relatively low mass emissions rates by a wet scrubber and an afterburner.
- Replacing the wet scrubber with a baghouse would increase sulfur dioxide emissions by approximately 23 tons per year.
- From review of the RACT/BACT/LAER Clearinghouse, Ohio EPA's Best Available Technology database and the United States Environmental Protection Agency National Emission Standards for Hazardous Air Pollutant Foundry ICR database, particulate matter may be controlled by a wet scrubber or baghouse. Volatile organic compounds are normally controlled with an afterburner. The annualized cost per ton to install a baghouse in lieu of the wet scrubber exceeds $10,000 per ton and would increase sulfur dioxide by amounts comparable to the reduction in particulate matter.
- Review of the RACT/BACT/LAER Clearinghouse data found only low nitrogen oxides burners installed in the afterburner as control for nitrogen oxides from cupolas. Emission rates range from 0.15 lb/ton to 0.44 lb/ton, with the most recent determinations at 0.44 lb/ton. Compliance has not been verified for any of the entries in the RBLC.

Section 1
Project Introduction and Overview

1.1 Project Introduction

Clow Water Systems Company's (Clow's) facility is classified as a Major Stationary Source under Prevention of Significant Deterioration (PSD) regulations (40 CFR Part 52.21). Particulate matter (PM), particulate matter less than 10 microns (PM_{10}), nitrogen oxides (NO_X), and volatile organic compound (VOC) emissions from the possible modification will exceed the respective PSD significance levels of 25 tons per year (tpy), 15 tpy, 40 tpy, and 40 tpy.

Clow is located in Coshocton County, Ohio, which is currently designated as an attainment area for PM/PM_{10}, and Ozone (VOC and NO_X).

PM, PM_{10}, and VOC emissions from the cupola are currently controlled by a wet scrubber and an afterburner. NO_X emissions are currently controlled by low NO_X burners installed on the cupola afterburner. Following the modification, annual maximum emission rates will be 33.0, 25.64, 63.25, and 37.13 tpy for PM, PM_{10}, NO_X, and VOC, respectively.

1.2 Study Methodology

The following was considered when developing the study methodology for the cupola:

- The PM, PM_{10}, and VOC emissions from the cupola are currently controlled to relatively low mass emissions rates by a wet scrubber and an afterburner. NO_X emissions are controlled by low NO_X burners on the cupola afterburner.
- The wet scrubber performs very well when compared to the population of wet scrubbers surveyed by United States Environmental Protection Agency (USEPA) during development of the Iron Foundry Maximum Achievable Control Technology (MACT).
- Replacing the wet scrubber with a baghouse would increase sulfur dioxide (SO_2) emissions by approximately 23 tpy.
- The significant level for VOC was exceeded because of the increased utilization of the existing painting operations. Because the VOC emissions from the cupola are currently controlled by the afterburner, a detailed cost-effectiveness analyses for the VOC control option was not completed.
- NO_X emissions from the cupola account for about two thirds of the predicted NO_X emissions increase from this project.

The study methodology for the cupola included:

- A review of the RACT/BACT/LAER Clearinghouse (RBLC) to determine a list of comprehensive and feasible control technologies.
- A comparison of the identified control technologies based on expected emission rate, emissions reduction, energy impacts, environmental impacts and cost effectiveness.
- Evaluation of the most effective control and a selection of Best Available Control Technology (BACT).

Section 2
Particulate Matter (PM) Emissions

2.1 RBLC Review Summary

A review of the RBLC was conducted. Research of the historical and transient databases was not completed because the control determinations in those databases would be over ten years old and would not likely represent current technology.

Applications in the RBLC and Ohio Environmental Protection Agency (Ohio EPA) Best Available Technology (BAT) database containing similar operations were identified and are included in tables in this section.

2.1.1 Cupola

Applications in the RBLC and Ohio EPA BAT database containing similar operations were identified and are included in Tables 2.1 and 2.2. It is unknown if the determinations included in the tables have been verified through stack testing.

Emission rates in pounds of particulate matter per ton of melt ranged from 0.078 to 0.34 in the RBLC and from 0.26 to 0.81 in the Ohio EPA BAT database.

Table 2.1
PM/PM_{10} RBLC Data

FACILITY	PERMIT NO. (date issued)	OPERATION DESCRIPTION	EMISSIONS LIMITS/CONTROL REQUIREMENTS (equivalent rate per ton processed)
Waupaca Foundry – Plant 5 (Tell City, IN)	CPP 123-4593 (5/31/96)	Iron Foundry Cupola (60 tons per hour [tph])	0.078 lb PM/ton 0.01 gr/dscf
Waupaca Foundry, Inc. (Tell City, IN)	123-8451 (2/01/99)	Cupola Existing (80 tph) and Cupola, Phase II (80 tph)	0.078 lb PM/ton 0.01 gr/dscf
Waupaca Foundry Inc., Plant 1 (Waupaca, WI)	91-RV-103 (12/01/92)	Cupola (with Hot Blast Burners, Afterburner)	0.34 lbs. PM/ton 0.064 gr/dscf

Table 2.2
PM/PM_{10} Ohio BAT Data

FACILITY	PERMIT NO. (date issued)	OPERATION DESCRIPTION	BAT DESCRIPTION
OSCO Industries Inc. (Portsmouth, OH)	0-7380 (NK)	Iron Melting Cupolas	0.812 lbs. PM/ton
GMC Powertrain Division (Defiance, OH)	03-7076 (1988)	60 tph Plasma Arc Cupola	0.26 lb/ton 0.03 gr/dscf

2.2 Identification of Control Technologies

2.2.1 Cupola

Historically, wet scrubbers have been used to control particulate emissions from cupola melting operations, though recent installations have included baghouses. From a review of the information submitted to USEPA for support of the Iron Foundry NESHAP development, no other control technology has been used for the control of particulates from the cupola.

2.3 New Source Performance Standard Applicability

No New Source Performance Standard (NSPS) is applicable to the cupola.

2.4 Evaluation and Selection of BACT

2.4.1 Cupola

The current wet scrubber yields a lower pound per ton emission rate than the cupolas with wet scrubbers identified in either the RBLC (Waupaca Plant 1) or the Ohio EPA BAT database (OSCO, GM Defiance). As an alternative to the existing wet scrubber, the cost effectiveness of installing a baghouse in lieu of the wet scrubber was evaluated. The spreadsheet for this evaluation, cost quote, and an article titled, "Cupola Emissions Controls: Wet Scrubber vs Dry Baghouse" is included in Appendix A.

Because the cost effectiveness already exceeds $10,000 per ton, additional costs, such as those associated with business interruption and site preparation have not been included. Clow is proposing continued use of the existing wet scrubber as BACT/BAT.

Section 3
Volatile Organic Compound (VOC) Emissions

3.1 RACT/BACT/LAER Clearinghouse Review Summary

A review of the RBLC was conducted. Research of the historical and transient databases was not completed because the control determinations in those databases would be over ten years old and would not likely represent current technology.

3.1.1 Cupola

Applications in the RBLC and Ohio EPA BAT database containing similar operations were identified and are included in Tables 3.1 and 3.2. It is unknown if the determinations included in the tables have been verified through stack testing.

Emission rates in pounds of VOCs per ton of melt ranged from 0.02 to 0.05 in the RBLC. No emission rates could be determined from the Ohio EPA BAT database.

Table 3.1
VOC RBLC Data

FACILITY	PERMIT NO. (date issued)	OPERATION DESCRIPTION	EMISSIONS LIMITS/CONTROL REQUIREMENTS (equivalent rate per ton processed)
Waupaca Foundry – Plant 5 (Tell City, IN)	CPP 123-4593 (5/31/96)	Iron Foundry Cupola (60 tph)	0.05 lb VOC/ton
Waupaca Foundry , Inc. (Tell City, IN)	123-8451 (2/01/99)	Cupola Existing (80 tph) and Cupola, Phase II (80 tph)	0.02 lb VOC/ton
Waupaca Foundry Inc., Plant 1 (Waupaca, WI)	91-RV-103 (12/01/92)	Cupola (with Hot Blast Burners, Afterburner)	0.05 lb VOC/ton

Table 3.2
VOC Ohio BAT Data

FACILITY	PERMIT NO. (date issued)	OPERATION DESCRIPTION	EMISSIONS LIMITS/CONTROL REQUIREMENTS (equivalent rate per ton processed)
OSCO Industries Inc. (Portsmouth, OH)	0-7380 (NK)	Iron Melting Cupolas	ND
GMC Powertrain Division (Defiance, OH)	03-7076 (1988)	60 tph Plasma Arc Cupola	ND

3.2 New Source Performance Standard Applicability

No NSPS is applicable to the cupola.

3.3 Evaluation and Selection of BACT

3.3.1 Cupola

The cupola currently maintains a temperature in the afterburner section of 1300°F and a 0.3-second residence time. From a review of the submittals to support the MACT, this continues to be the standard. Clow recommends the continued use of the afterburner as BACT/BAT for VOC from this source.

Section 4
Nitrogen Oxide (NO_X) Emissions

4.1 RACT/BACT/LAER Clearinghouse Review Summary

A review of the RBLC was conducted. Research of the historical and transient databases was not completed because the control determinations in those databases would be over ten years old and would not likely represent current technology.

4.1.1 Cupola

Applications in the RBLC database containing similar operations were identified and are included in Tables 4.1. The RBLC notes that compliance has not been verified for the determinations included in the tables.

Emission rates in pounds of NO_X per ton of melt ranged from 0.15 to 0.44 in the RBLC, with all of the more recent determinations at 0.44. No BAT determinations for NO_X were found in the Ohio EPA BAT database.

Table 4.1
NO_X RBLC Data

FACILITY	PERMIT NO. (date issued)	OPERATION DESCRIPTION	EMISSIONS LIMITS/CONTROL REQUIREMENTS (equivalent rate per ton processed)
Waupaca Foundry, Inc. (McMinn, TN)	952943P (08/24/2001)	Phase I Cupola	0.44 lb NO_X/ton (Low NO_X Burners)
Waupaca Foundry, Inc. (McMinn, TN)	952943P (04/28/2000)	Cupola	0.44 lb NO_X/ton (Using low NO_X burners in the recuperative incinerator)
Waupaca Foundry, Inc. (McMinn, TN)	952945P (04/28/2000)	Cupola	0.44 lb NO_X/ton (Using low NO_X burners in the recuperative incinerator)
Waupaca Foundry Plant – 2 & 3 (Waupaca, WI)	99-RV-009 (07/16/1999)	Cupola, P51, S51	0.44 lb NO_X/ton (low NO_X burners in the recuperative incinerator)

Table 4.1
NO_X RBLC Data (continued)

FACILITY	PERMIT NO. (date issued)	OPERATION DESCRIPTION	EMISSIONS LIMITS/CONTROL REQUIREMENTS (equivalent rate per ton processed)
Waupaca Foundry, Inc. (Perry, IN)	123-8451 (02/04/1998)	Cupola, Existing	0.44 lb NO_X/ton (Low NO_X burners on the recuperative incinerator)
Waupaca Foundry, Inc. (Perry, IN)	123-8451 (02/04/1998)	Cupola, Phase 2	0.44 lb NO_X/ton (Low NO_X burners or incinerator)
Waupaca Foundry – Plant 5	CPP 123-4593 (1/19/1996)	Iron Foundry Cupola	0.15 lb NO_X/ton (Low NO_X burner recuperative combustor/heat recovery system)

4.2 Identification of Control Technologies

A review of the RBLC database identified low NO_X burners as the only method of NO_X control employed on cupolas. SCRs and SNCRs though not installed on any cupola are discussed below.

4.2.1 Selective Catalytic Reduction (SCR) Technology

Selective Catalytic Reduction (SCR) technology uses ammonia or urea as a reactant to catalyze NO_X to nitrogen (N_2) and water. To be effective it requires an exhaust gas that is relatively free of particulate matter, and an exhaust gas temperature of approximately 550°F to 750°F. In a cupola the temperature, and pollutant concentration vary depending on whether the burners in the afterburner section are at low-fire or high-fire. Additionally, coke additions are made to the cupola throughout the melt and NO_X formation from conversion of nitrogen-containing compounds in the coke add to the overall NO_X from the cupola. These factors will inhibit effective control as the reactant (ammonia [NH_3] or urea) feed rate would need to be adjusted rapidly throughout the melt.

There are two options for location of an SCR system, in the exhaust from the cupola, or on the clean side of the scrubber system. The advantage of placing the SCR in the cupola ductwork is the temperature of this exhaust system may be within the effective range of SCR technology. However, the exhaust gases will be heavily laden with particulate matter at this location and quickly foul the catalyst rendering it useless. Therefore, installation of a control device to remove PM prior to the SCR would be required. Additionally, since the temperature is expected to be quite high at this point in the exhaust stream, approximately 1300°F, any control device installed here would need to be capable of operating at temperatures higher than normal or the option of cooling the exhaust stream via condensor or dilution air would be necessary. Operation of a baghouse at the desired temperature, approximately 1300°F, would require installation of fiberglass filter media. However, the NO_X emission rate will still fluctuate substantially during the melt, requiring the reactant (NH_3 or urea) feed rate to vary accordingly so as to limit emissions of these materials to the atmosphere.

If the SCR is placed on the clean side of the particulate air pollution control system, the exhaust gas temperature will already be at a level compatible with normal baghouse fabric, approximately 185°F. However the temperature of the exhaust stream would need to be heated to raise the temperature to within the acceptable operating range for SCR technology, approximately 550°F to 750°F. The energy required to raise the temperature of the exhaust gas to the appropriate range will consume a significant amount of natural gas at a substantial cost and result in emissions of combustion products. Additionally, locating the SCR after the air pollution control system will not alleviate the variation in the NO_X generation and corresponding required variable reactant feed rates. For these reasons SCR technology is not a technologically feasible option.

4.2.2 Selective Non-Catalytic Reduction (SNCR) Technology

Selective Non-Catalytic Reduction (SNCR) is determined to be not feasible for NO_X control on cupola scrubber system exhaust for similar reasons. First, it is not possible to maintain the near stable gas conditions needed to control NO_X by employing SNCR technology. Secondly, the highly variable NO_X concentration in the gas stream makes it impractical to maintain the proper stoichiometric ratio of reagent, which would likely result in significant ammonia slip and reduced efficiency. Thirdly, like SCR, it would not be feasible to install this device without particulate matter filtration prior to the SNCR unit. Finally, SNCR technology is not effective in the temperature ranges of the cupola exhaust system. SNCR is only effective in the range of 1,600°F to 2,000°F. The cupola exhaust temperature following the air pollution control device averages approximately 185°F. Therefore, the exhaust stream would need to be heated to even approach the low end of the SNCR temperature range. This heating would require substantial energy and produce additional NO_x and carbon monoxide (CO) emissions. Therefore, SNCR was not further considered as a control option.

4.3 New Source Performance Standard Applicability

No NSPS is applicable to the cupola.

4.4 Evaluation and Selection of BACT

4.4.1 Cupola

The Cupola currently has low NO_x burners installed on the afterburner. This is consistent with recent determinations for similar units found in the RBLC. Therefore, no further control is proposed.

Appendix A
Cupola PM/PM_{10} Control Option #1
Cost-Effectiveness Analyses
and Supporting Data

Clow
Annualized Cost Analysis
Cupola Wet Scrubber to Baghouse Conversion

Cost Item	Average Cost Factor	Adjustment Factor	Cost ($)	Basis of Costs
Capital Costs:				
Engineering				
Business Interruption				
Control Equipment				
Ancillary Equipment				
Facilities				
Miscellaneous				
TOTAL CAPITAL COSTS (Direct + Indirect)=			$ 5,754,500	Quote from Modern Equipment Company for an 85 tph cupola
Cost Item	$/unit	units/yr	Cost	
Direct Operating Costs:				
Operating Labor:				
Operator ($/HR X HRS/YR)			$ -	
Supervision(15% of labor)			$ -	
Operating Materials:				
Maintenance (general):				
Labor			$ -	
Materials (100% of labor)			$ -	
Replacement parts (as required)				
Labor (100% of parts cost)			$ -	
Utilities:				
Electricity ($/KWHxKWH/yr)			$ -	See Below
Fuel oil ($/gal x gal/yr)			$ -	See Below
Gas ($/$10^3$ft^{3}x 10^3/yr)			$ -	See Below
Water (10^3 gallon)				See Below
Steam			$ -	See Below
Other			$ -	See Below
			$ -	
Waste Disposal (gallons)			$ -	
Wastewater Treatment			$ -	
TOTAL DIRECT OPERATING COSTS (A)=			$ -	
Indirect operating (fixed) costs:				
Overhead	60% of O & M labor/materials		$ -	
Property Tax	1% of capital costs		$ -	
Insurance	1% of capital costs		$ -	
Administration	2% of capital costs		$ -	
Capital Recovery CRF=	0.1168	$5,754,500	$ 672,298	
	(8.0% for 15 years)			
TOTAL FIXED COSTS (B)=			$ 672,298	
Credits:				
Product recovery				
Heat recovery				
TOTAL CREDITS (C)=			$ -	
TOTAL ANNUALIZED COSTS (A +B minus C)=			$ 672,298	
Difference in Operating/Maintenance Costs			($360,250)	Article entitled "Cupola Emission Controls: Wet Scrubber vs. Dry Baghouse"
TOTAL ANNUALIZED COSTS LESS DIFFERENCE IN OPERATING AND MAINTENANCE COSTS			$ 312,048	
Controlled Emissions (tons/year)=			19.94	PM10 stack emission rate minus .01 gr/dscf
Cost ($/ton)=			$ 15,652	

TOTAL RETROFIT COST ESTIMATES FOR CUPOLA WET SCRUBBER SYSTEMS

TPH	Total Retrofit	EPA Foundries	Total Cost	Additional Foundries	Total Cost
10	$1,453,250	$ 1	$ 1,453,250		$ -
15	$1,740,000		$ -		$ -
20	$2,026,750		$ -	$ 1	$ 2,026,750
30	$2,600,250	$ 2	$ 5,200,500	$ 1	$ 2,600,250
40	$3,173,750		$ -	$ 1	$ 3,173,750
50	$3,747,250	$ 2	$ 7,494,500	$ 1	$ 3,747,250
60	$4,320,750	$ 3	$12,962,250		$ -
70	$4,894,250		$ -		$ -
80	$5,467,750	$ 2	$10,935,500		$ -
90	$6,041,250	$ 1	$ 6,041,250		$ -
100	$6,614,750		$ -		$ -
Total			$44,087,250		$ 11,548,000

TPH	Without burner and recup	EPA Foundries	Total Cost	Additional Foundries	Total Cost
10	$ 704,500		$ -		$ -
15	$ 855,000		$ -		$ -
20	$1,005,500		$ -	2	$ 2,011,000
30	$1,306,500	1	$ 1,306,500	2	$ 2,613,000
40	$1,607,500	2	$ 3,215,000	1	$ 1,607,500
50	$1,908,500	5	$ 9,542,500		$ -
60	$2,209,500	2	$ 4,419,000		$ -
70	$2,510,500	1	$ 2,510,500		$ -
80	$2,811,500	2	$ 5,623,000		$ -
90	$3,112,500		$ -		$ -
100	$3,413,500	2	$ 6,827,000		$ -
Total			$33,443,500		$ 6,231,500

Total EPA Foundries	$ 26	based on 26 foundries in long form
Total foundries	$ 9	based on 9 foundries (not in long form) but Believed to have MACT applicability.
Total EPA cost	$77,530,750	based on 26 foundries in long form
Additional foundries cost	$17,779,500	based on 9 foundries (not in long form) but Believed to have MACT applicability.
Total estimate	$95,310,250	

Guidelines were followed, to the best of our ability.
Estimates ARE included for recuperation, gas cooling and burner systems for those foundries that have no recup or burner systems. This was done because recuperation and gas cooling offer an economical Means of heat recovery and energy conservation for hot blast cupolas.
In addition, recuperation and proper (DRY) gas cooling are key design features in minimizing gas handling system size (capital cost), and increasing operational efficiency, minimizing problems and affording heat reuse in the foundry for other processes Including makeup air heating.

Submitted by: David Kasun, P.E., Process Engineer
Modern Equipment Company, May 5, 2000

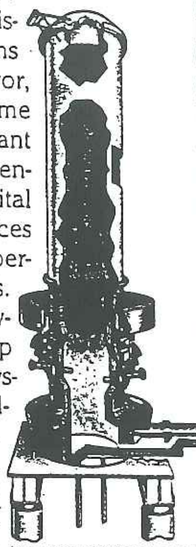
Attachment D

Cupola Emissions Controls: Wet Scrubber vs. Dry Baghouse

By comparing the wet and dry emissions controls at Neenah Foundry, you can make an informed decision on whether or not a system change makes sense.

David J. Kasun
Neenah Foundry Co., Neenah, Wisconsin

CUPOLA MELT REPORT



Art courtesy of Chicago Fire Brick Co.

The decision to change foundry emission control systems can be an expensive endeavor, potentially exhausting both time and money. In an area important to both public perception and environmental compliance, it's vital to stay on top of the best choices for your foundry in terms of operating requirements and costs. Your best course of action, however, isn't necessarily to scrap your current emission control system in favor of the most advanced system on the market.

A baghouse, or dry, system is capable of extremely low emission rates and lower operating costs, but if experience isn't an integral part of the system design, you can have many costly problems, including failed bags, poor dust handling, bridging of dust in the hoppers and excessive corrosion. If regulations allow you to keep or update your wet system by making simple, less costly modifications, you might want to bite the bullet on operating costs.

Regulations undoubtedly will drive the need to upgrade emissions control, but, keeping in mind the high cost of completely changing systems, you may be wise to wait until change is absolutely required. Using Neenah Foundry Co.'s experience with both wet and dry emissions control, you can compare operating costs to decide what's best for your operation: updating or changing your emission systems or doing nothing at all.

This article highlights the differences between a high-energy venturi wet scrubber and a pulse jet baghouse, including a comparison of cupola particulate control operating costs and the incremental cost of upgrading a wet system to a higher efficiency baghouse.

Neenah's Rationale

Neenah operates two cupola melt foundries, Plant 2, a 600-ton/day gray iron municipal/industrial casting shop, and Plant 3, a 500-ton/day ductile iron industrial casting shop. Both cupolas are the same size and style and are capable of similar melt rates, but they operate with different emission control systems. Plant 2 uses a pulse jet dust collector, while Plant 3 uses a high-energy venturi wet scrubber.

Originally, Neenah updated existing wet scrubbers on both cupolas in 1989. In 1991, regulatory requirements necessitated that the efficiency of the scrubber in Plant 3 be increased. Due to numerous design flaws, including the lack of a variable throat venturi and the absence of a water treatment system, the scrubber was not capable of achieving acceptable emission rates. Neenah started fixing one problem at a time, but when all was said and done, the cost of "fixing" the problem was much higher than expected.

At the time, Plant 2's scrubber was operating acceptably, but it was of marginal capacity. Knowing what was spent to make Plant 3 efficient, combined with increasing melt rates ad tighter environmental regulations, Neenah decided that it would be more cost effective to install a new baghouse system.

Baghouse Cupola

To understand operating costs associated with the system, it's first necessary to understand the cupola and emissions control setup in both foundries. Plant 2 melts with an 84-in. acid-lined, front-slagging, above charge take-off cupola with 1000F (538C) hotblast and tuyere oxygen injection. The cupola typically melts 24-29 tons/hr. The upper stack combustion system utilizes a refractory gas-mixing orifice, two 6 million Btu/hr main afterburners and two 1.5 million Btu/hr pilot gas burners for carbon monoxide (CO) combustion. Two 10 gal/min-maximum stack sprays also are installed just above the burners for temperature control during upset and burn down conditions.

Hot off gases enter a large drop out chamber fitted with five 10 gal/min-maximum air/water sprays for fly ash removal and recuperator inlet temperature control. Hot gases pass through a long, refractory-lined duct to a vertical heat exchanger and exit the recuperator at approximately 900F (482C). Gases then enter an 8-ft-diameter, 40-ft-tall gas-cooling tower with 10 4 gal/min-maximum

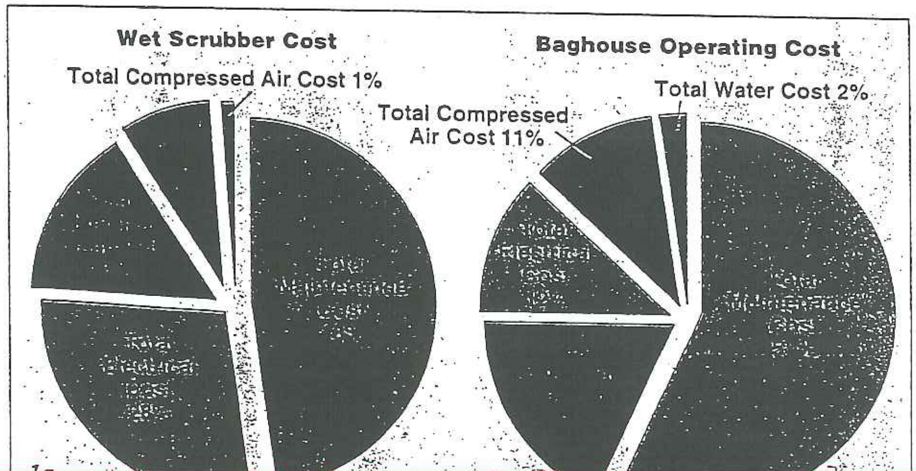


Fig. 1a-1b. These pie charts break down maintenance, electrical, compressed air, water and chemical treatment costs as a percentage of total operating costs for each system at Neenah. Maintenance is the greatest operating expense for both systems, but while chemical treatment is the second highest cost in the baghouse system, electricity places second for the wet scrubber system.

air/water spray nozzles that cool the gases to near baghouse inlet temperature (about 550F [288C]).

Cooled gases pass through a large, low-pressure drop spark arrestor prior to entering the baghouse at 450F (232C). Dust stabilizing reagent is added immediately prior to the baghouse, a pulse jet collector with 10 cells that are isolated one at a time for off-line cleaning. The filter medium is an acid-resistant woven 22-oz fiberglass with an expanded PTFE membrane. The baghouse exhausts through a high-efficiency airfoil fan powered by a variable-frequency drive for flue gas volume and cupola upper stack temperature control. The baghouse's tube sheet pressure differential operates in the range of 3-5 water column in. Using screw conveyors, dust is transported from the baghouse into a small silo, which feeds a high-speed pin mixer for wetting the dust prior to placement in a landfill. Upper stack temperatures are maintained at a constant 1550F (843C) ±50F during melting by continuously controlling the exhaust volume using the fan's variable-frequency drive.

Wet Scrubber Cupola

The cupola at Plant 3 is virtually identical to the one in Plant 2, but a wet system is used to control emissions. The difference in the cupola setup is Plant 3's slightly lower melt rate, in the 22-27 tons/hr range, and slightly higher coke ratios for metallurgical reasons. Hot-off gases enter a water spray quencher in which the gas stream is boosted to saturation. The saturated gas enters a variable-throat venturi and passes through a flooded elbow into a chevron demister with city water face sprays before entering into a high-static pressure radial blade fan. A venturi is essentially a restriction in the ductwork that accelerates the gases, and the position of the venturi plug is continuously adjusted to control exhaust gas volume to maintain an upper stack temperature of 1550F (843C). The fan always is operated at its full load amperage (and static pressure). This way, the maximum pressure drop (and maximum scrubbing) is maintained across the venturi throat. Fan static pressure operates at about 60 in. of water column static pressure.

Dirty quencher water drains to a large drag chain tank for removal of fly ash and grit before being pumped back to the quencher. The dirty scrubber water from the flooded elbow and demister drains into an 8000-gal flocculation tank in which pH is controlled using magnesium hydroxide. Flocculation is the act of adding a cationic polymer to dirty water to gather together the suspended particulate, allowing it to settle out.

The flocculated effluent then is clarified in a 14,000-gal sludge contact/inclined plate clarifier; the solids are pumped to a sludge-thickening tank. Twice per day sludge is pumped into a 60-cu-ft frame-and-plate filter press where it is dewatered and discharged into a 6-ton hopper that empties into dump trucks headed for the landfill.

A sidestream of clean hot water from the clarifier is discharged at a rate of 45 gal/min to the sanitary sewer for control of dissolved solids in the water system.

Table 1. Cost Comparison Between Wet Scrubber and Baghouse Operation at Neenah

	HIGH ENERGY WET SCRUBBER			BAGHOUSE		
Electrical Costs (Horsepower)	HP Installed	Average Actual HP	Annual Operating Cost	HP Installed	Average Actual HP	Annual Operating Cost
Exhuast fan	600	600	$116,376.00	400	150	$29,094.00
Quencher, venturi and cooling tower pumps	100	85	$16,486.60	0	0	$0.00
Scrubber cooling tower fan	25	22	$4,267.12	0	0	$0.00
Pelletizer dust mixer	0	0	$0.00	25	25	$1,212.25
City booster pump	20	15	$2,909.40	15	10	$1,939.60
Rotary airlocks and augers	0	0	$0.00	40	25	$4,849.00
Quencher sump, clarifier drag chain drives	8	5	$969.80	0	0	$0.00
Mag hydroxide and floc tank mixers	8	5	$969.80	0	0	$0.00
Total	761	732	$141,978.72	480	210	$37,094.85
Compressed Air Consumption (SCFM)		Avg SCFM	Cost		Avg SCFM	Cost
Pulse jet air (baghouse)		0	$0.00		27	$2,527.20
Mag hydroxide and clarifier sludge air pumps		100	$1,965.60		0	$0.00
Cupola stack cooling spray nozzles		50	$4,680.00		50	$4,680.00
Gas cooling nozzles		0	$0.00		340	$31,824.00
Sludge filter press pump		65	$760.50		0	$0.00
Total		215	$7,406.10		417	$39,031.20
City Water Consumption/Disposal		Avg GPM	Cost		Avg GPM	Cost
Cupola stack cooling spray nozzles		0.1	$36.19		0.1	$36.19
Gas cooling nozzles		0	$0.00		21.5	$7,781.28
Quencher water makeup		70	$25,334.40		0	$0.00
Sanitary sewer blowdown		45	$16,252.00		0	$0.00
Pelletizer water mixture		0	$0.00		0.2	$72.38
Total		115.1	$43,622.59		21.8	$7,889.86
Chemical Costs		Avg lb/ton melt	Cost		Avg lb/ton melt	Cost
Baghouse dust reagent		0	$0.00		2.2	$62,634.00
Magnesium hydroxide (pH control)		2.7	$78,097.50		0	$0.00
Total			$78,097.50			$62,634.00
Maintenance Costs						
Labor $			$121,449.33			$89,478.87
Stockroom and direct material			$103,758.67			$88,545.34
Outside matl + labor			$8,088.00			$8,918.67
Total			$233,296.00			$186,942.88

Total Cost	Total Annual Cost		Dollars/Ton Collected PM		Dollars/Ton Iron Melted	
	WET	DRY	WET	DRY	WET	DRY
Total electrical cost	$141,978.72	$37,094.85	$161.86	$41.51	$1.09	$0.29
Total compressed air cost	$7,406	$39,031	$8.44	$43.68	$0.06	$0.30
Total water cost	$43,623	$7,890	$49.73	$8.83	$0.34	$0.06
Total chemical treatment cost	$78,098	$62,634	$89.03	$70.10	$0.60	$0.48
Total maintenance cost	$233,296	$186,943	$265.97	$209.22	$1.79	$1.44
TOTAL OPERATING COST	$504,401	$333,593	$575.04	$373.34	$3.88	$2.57

$1.31

The remaining clean hot water is cooled by a 12 million Btu/hr cooling tower before being pumped back to the venturi for scrubbing. The venturi spray water typically operates at 90F (32C) with a suspended solids content of less than 50 ppm. The use of cool, clean water has improved scrubbing efficiency as well as general systems operation.

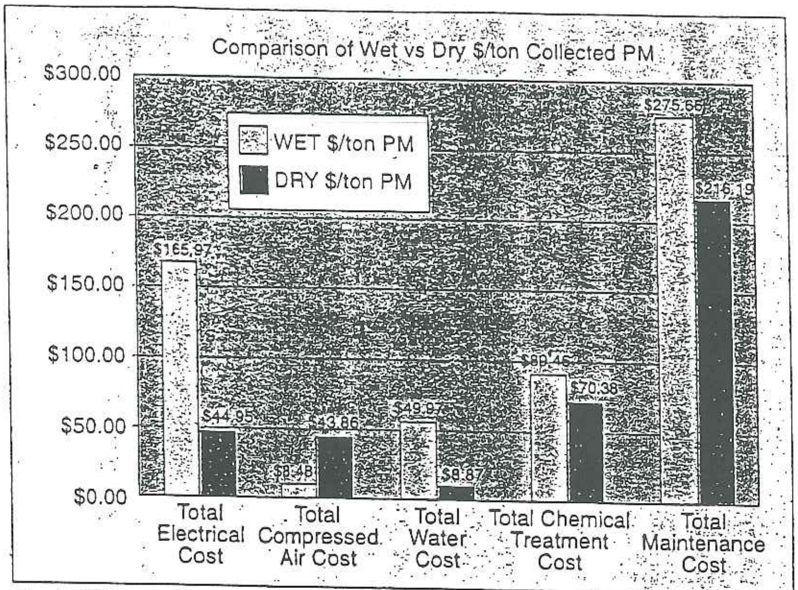


Fig. 2. This graph compares the wet and dry systems at Neenah in terms of dollars per ton of PM. The wet system is more expensive in every cost area except for the compressed air total.

Cost of Emission System Operation

For both emission systems, the cost of operation was analyzed (Table 1), excluding capital depreciation, landfill disposal costs and major equipment replacements. Maintenance costs were tallied over 9 months and prorated for an annual total. For the purpose of calculating compressed air, electrical and water consumption, and chemical costs, both cupolas were assumed to be operating on blast at 20 hr/day, 260 days/year at a 25-ton/hr melt rate, with an equivalent output of 130,000 tons of iron. Operating costs for off-blast periods were excluded for the sake of obtaining a production rate comparison. However, the off-blast operating cost for the wet scrubber is substantially higher than that for the dry system due to the higher connected horsepower (hp) associated with the exhaust fan and water system pumps.

Operating Cost

The overall operating cost of the wet scrubber at Neenah is 1.5 times greater than that of the dry system, or $575.04/ton of particulate matter (PM) for the wet system and $373.34/ton PM for the dry system.

The electrical cost associated with the high fan hp of the wet system and associated water system pumps (that operate continuously) are the primary energy consumers. The lower design static pressure of the baghouse conserves energy. This, combined with a low tubesheet differential pressure, results in a low-hp system.

Electrical cost for the baghouse system, however, is offset greatly by the high cost of air-atomized cooling sprays that are needed in a system with only partial heat recuperation. Compressed air often is the most overlooked and one of the highest cost energy sources in the foundry. High-efficiency sprays are needed, however, to prevent water-related system problems. For this reason, a system should recuperate flue gas to the greatest extent possible. Recovering (or wasting) heat without the use of water in a dry system will conserve energy, coke, water and compressed air and prevent the condensation of acids associated with high moisture levels in the dry system.

Maintenance costs for the wet system appear to be only slightly higher than those of the baghouse, but represent a much larger percentage of the total operating cost for the baghouse due to the lower total annual operating cost.

Collector Efficiencies

Particulate grain loadings for the wet system are nearly 10 times higher than those for the baghouse, but the total emission rate is only 5 times higher. This is attributable, in part, to the smaller volume of gas associated with the cooler saturated gas stream in the wet system.

The PM control efficiency of a properly engineered and operated wet scrubber nearly approaches that of a dry system (Table 2). If one looks at the incremental cost of control per ton of PM to replace a wet scrubber with a baghouse (at the cost of $2 million) it is apparent that to collect the extra 17.2 tons/year PM out of a potential 890 tons/year, the incremental cost of control can well exceed $100,000/ton PM.

Public perception is perhaps one of the most obvious and non-technical differences between the two systems. The dry system has no visible plume except during the coldest days, while the water vapor exhaust of the wet scrubber implies environmental degradation to the public. This may or may not be a good justification for replacement of a properly operating wet system.

Combustion and CO Recuperation

The cost to operate a recuperative hotblast at Neenah is much less than that of operating a natural gas-fired preheater. The related benefits of cooling cupola gases without the use of water for dry collectors are very substantial. Some of the benefits are: reduced flue gas volume (smaller fan, less hp), lower moisture content in the flue gas, less ductwork corrosion, smaller ductwork, lower air-to-cloth ratios, reduced baghouse size and reduced spray nozzle compressed air usage. While the control of CO continues to gain prominence, the effective recovery of heat from CO combustion for process air preheat and metallurgical control significantly improves overall system efficiency while reducing operating costs. ▼

Table 2. PM Control Efficiency Comparison at Neenah

Emission Estimates	WET	DRY
Average melt rate (during test) tons/hr	25	25
Total annual melt (tons iron)	130,000	130,000
Uncontrolled PM (13.8 lb/ton AP42) lb/hr	345	345
Actual emission rate (front half only) lb/hr	7.63	1.33
Emission rate (front half only) grains/dry standard cu ft	0.0410	0.0049
Control efficiency (front half only)	97.79%	99.61%
Total controlled emission factor (front only) lb/ton	0.305	0.053
Total annual uncontrolled PM (130,000 tons melt)	897.0	897.0
Total annual emissions tons/year	19.8	3.5
Total controlled (collected) PM tons	877.2	893.5

This article was adapted from a presentation at the 1998 AFS 2nd International Cupola Conference. Conference proceedings are available from AFS Publications at 800/537-4237.